[redacted]

ON THE INTRODUCTION

OF

CONSTRUCTIONS

TO RETAIN THE SIDES OF DEEP CUTTINGS IN CLAYS, OR OTHER UNCERTAIN SOILS.

William

By PROFESSOR HOSKING.

1 =

ABSTRACT OF THE PAPER, AND OF THE DISCUSSION UPON IT.

EXCERPT MINUTES OF PROCEEDINGS

OF THE

INSTITUTION OF CIVIL ENGINEERS.

N.

1844.

LONDON:
Printed by WILLIAM CLOWES and SON
Stamford Street.

INSTITUTION OF CIVIL ENGINEERS.

June 25, 1844.

The PRESIDENT in the Chair.

No. 689. "On the introduction of Constructions to retain the sides of deep Cuttings in Clays, or other uncertain soils." By Professor Hosking.

Constructions in deep Cuttings.

Deep cuttings are not only expensive, but their sloped sides are in most soils so uncertain, and subject to so many contingencies—involving unforeseen outlay, as well as danger to the works, and incidently to human life also;—that any mode of operation, which would have the effect of rendering them more secure, though the original expense were not reduced, would be deserving of consideration; but if it can be shown, that perfect security can be obtained at reduced cost, the consideration becomes even more interesting.

The expense of the first formation of a cutting under given circumstances is easily calculable, and so is the time within which the work may be effected. Experience has proved that there is, for every soil, a limit in depth, beyond which it becomes more expedient to drift the required way, and construct an arched tunnel of sufficient dimensions, than to make an open cutting with the requisite slopes. Even when the first cost would not decide the question, the preference is nevertheless, often given to the tunnel because of the greater security of constructed work, than of the sides of an open cutting. There is, indeed, in practice, a considerable range, within which it has always been uncertain whether—taking all things into consideration in each particular case—tunnelling or open cutting is the fitter expedient and it is in this intermediate range, that something seems to be desirable, which has not hitherto been practised.

A tunnel, it may be remarked,' is expensive, not from the nature and extent of its constructions, but from the circumstances in which those constructions must be executed. The mere constructions are less than would be consumed by common retaining walls to the sides of a cutting, not deeper than the height of an ordinary railway tunnel.

B 2

The several parts of a tunnel derive support
is not the case with ordinary retaining walls,
wholly upon the resistance which their ov
extent of base, enable them to offer to the pr
retained. If to two opposite retaining wa
means of assisting one another, they may be
third of the bulk they require without such as
be as safe as the sides of a constructed tunne
is only limited by the power of the setting m
work, to resist compression.

Before proceeding to the consideration of
opposite retaining walls to assist each other,
to consider, whether retaining walls are gene
a manner, as best to adapt their compon
performed.

No one would place a buttress intended
arch, within the springing walls, or under th
be resisted; yet in the construction of retai
fort is placed on that side which receives
utility is very questionable, except to keep
falling back against its load, which, from th
generally given to such walls, they would be
not so propped up by their counterforts.
and the revetment walls of military works, n
unbroken by projections in front, but this is
ing walls for roads and railways, where a
buttresses would be unobjectionable, the
buttresses and merely changing places with t

On account of the common practice of
retaining walls in curved lines and of rad
brickwork composing them from the centr
part, the back of the wall must contain m
the face, with the same quantity of solid bric
be bonded through. Hence the back of the
to compression and settlement than the face.
built in the same courses, and consequentl
beds of compressible mortar than the wall,
wall and its counterfort must be dropped, a
become utterly inefficient.

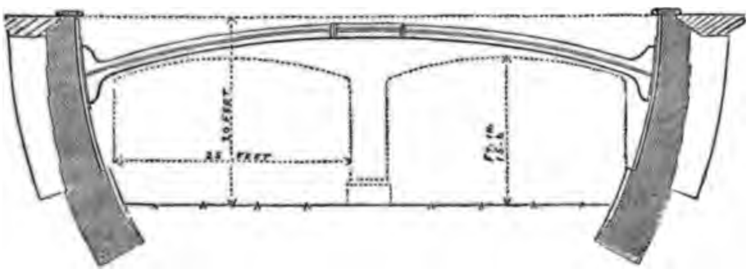
Perceiving the fallacy of the back counte
retaining wall to resist pressure from behind
retaining wall a few years ago, with greater
the usual practice would require, but witl

The wall was substantially of brickwork, with concrete coffered in the heart, to give mass and weight without the expense of solid brickwork; the concrete being in layers of 30 inches thick, separated from one another by two thorough courses of brickwork in every twelve courses in height. The wall was battered in face upon a curved line and had radiating courses of brickwork; but the arrangement spoken of, gave the means of making the longer line of the back of the wall with bricks instead of mortar, by inserting within the height of each coffer at the back, an additional course of brickwork; and the whole construction was well tied together, both longitudinally and transversely, with hoop-iron laid between the thorough courses of brickwork About 500 feet of this wall was executed in the wet summer and autumn of 1839; but the poverty of the Company, to whom the works belonged, prevented the execution of the drains to relieve the cutting and the formation of the roads above and below, which would have protected the wall from surface water behind and have added to its power of resistance in front. The consequence was, that on the breaking up of the severe frost which followed the floods in the winter of 1840, the wall was in one part forced forward and, the same circumstances leaving it still exposed for two or three years, a length of 300 feet was quite destroyed; whilst the remaining length of 200 feet, equally exposed at the toe, but protected from access of water behind, remained undisturbed. What is particularly to be remarked here is, that the wall went forward bodily, sliding with its concrete foundation upon the clay and pressing before it the mere sludge, which the undrained cutting had allowed the rain to make, but retaining its vertical position and profile as it had been built. Counterforts behind the wall could not, in this case, have done anything to assist it; but buttresses before the wall, might have rendered some aid, and struts from opposite walls would have effectually prevented it from moving forward, as long as they remained firm.

The retaining walls, in the cutting upon the line of the extension of the London and Birmingham Railway, from Camden Town to Euston Square, are designed according to the common practice; they are built wholly of brickwork in radiating courses and with counterforts following their own contour. In this case the centre of gravity of the wall falls wholly behind its base; and the counterforts, not commencing until the wall has reached one-third its height, render it still more dependent for support upon the ground it is intended to retain. It is well known that these extensive walls, though furnished with all the collateral works necessary to protect them from exposure to undue influences and although set nearly one-fourth

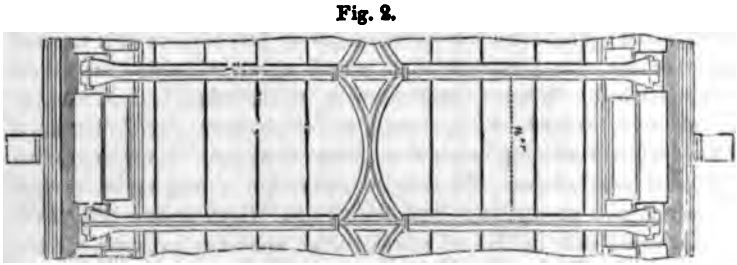
of their height in the ground, have failed to a considerable extent. A system of strutting with cast-iron beams, across from the opposite walls, to make each aid the other, has been applied to meet the exigency (Figs. 1 and 2); but this is limited to the upper parts of the walls and the author thinks it may yet be found, that the toes of the walls will require to be strutted apart, or otherwise fortified.

Fig. 1.



Transverse section of the Euston Incline retaining walls, &c.
(The dotted lines indicate the outline of one of the galleries.)
Scale.—1 inch to 20 feet.

Fig. 2.

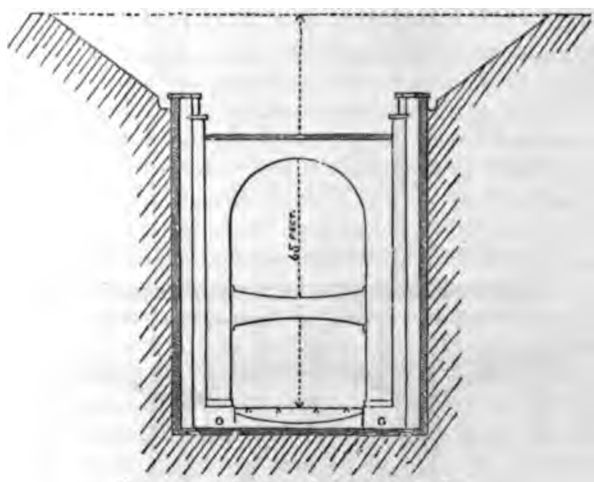


Plan.

Abutting struts from opposite walls, occurring at intervals only, leave the intermediate portions of the walls exposed to pressure from behind without support, unless these intermediate portions are so disposed, as to communicate the pressure upon them to the struts. Hence a common retaining wall, abutted at intervals, would require these intervals to be more or less distant, in proportion to the strength of the wall between them. Instead, therefore, of a continuous wall on each side of the cutting, the author suggests (Figs. 3, 4, 5, and 6), that buttress walls should be placed at intervals, opposite to one another, and strutted apart at their toes by an inverted arch, and above, at a height sufficient for whatever traffic the cutting is to accommodate, by a built beam of brickwork, in vertical courses,

supported on an arch, and prevented from rising under the pressure by an invert upon it. This built beam will then be, as it were, a piece of walling turned down on its vertical transverse section, and will resist any pressure brought upon it through the buttress walls, to the full extent of the power of such a wall built vertically, to bear any weight laid upon its summit; the pressure would be applied, in the line of the greatest power of resistance, and there would be no tendency to yield, except to a crushing force. Let such transverse buttress walls, so strutted apart, with the road between them, be the springing walls of longitudinal counter-arched retaining walls, which, being built vertically and in horizontal courses, but arched in plan,

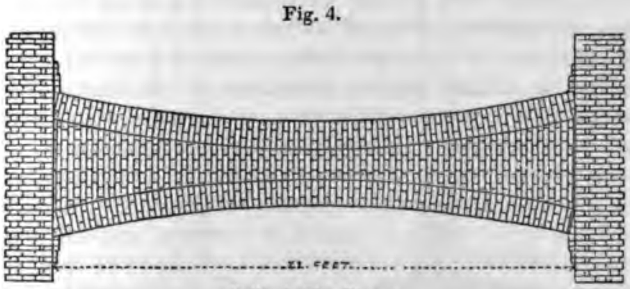
Fig. 3.



Transverse section through the centre of a Bay.

SCALE.—1 inch to 32 feet.

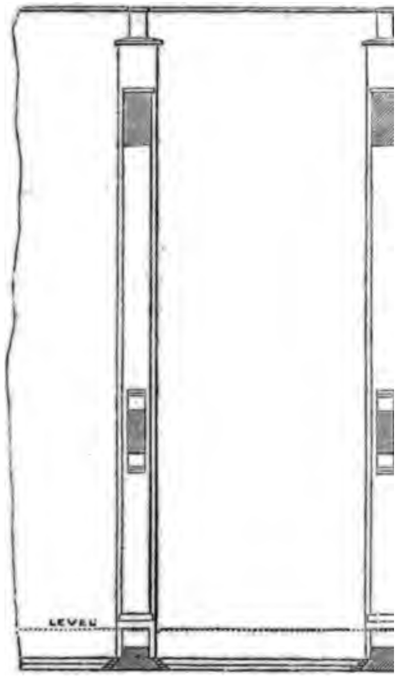
Fig. 4.



Built abutting Beams.

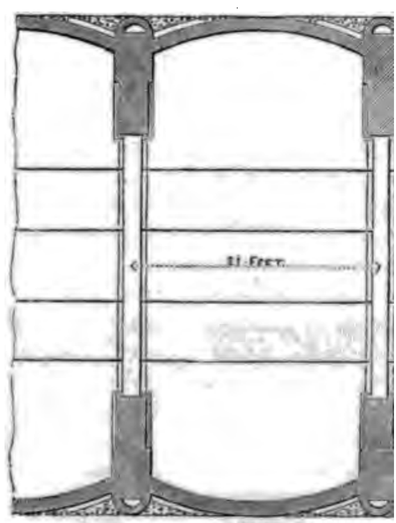
SCALE.—1 inch to 8 feet.

Fig. 5.



Longitudinal section. SCALE.—1 inch

Fig. 6.



Plan.

against the ground to be retained, will carry all the force exerted against them to their springing walls and the springing walls or buttresses will communicate, through the struts, the power of resistance of each side to the other and thus insure the security of both.

This arrangement may be carried to any extent in height, by repeating the abutting beam or strut at such intervals as the thrust to be resisted and the strength of the buttress springing-walls may require.

To constructions thus arranged, any requisite power may be given, by altering the quantity of materials in each part; the length of the buttresses transversely of the cutting,—the number of struts to each pair of buttresses,—or the length of the compartments. The thickness of the buttresses should be in proportion to their height and length, and their length should be in proportion to the flatness and weight of the struts, with their arches and to the space in height between any two of them, as well as to the magnitude of the thrust brought to them by the counter-arched retaining walls. The inverted arch below and the built beam above, must, of course, have sufficient substance to enable them to resist, without yielding in any direction, the pressure brought to them through the buttresses, and the retaining walls themselves must have substance given them according to their height,—to the pressure they are liable to receive from behind,—to the length of the compartments—and the extent of their flexure—and of course, with all the other parts of the work, according to the nature of the materials, workmanship and mode of construction.

In cases where constructions are not necessary to safety, nor required by the nature of the case, their aid will not be sought, unless they can be applied as cheaply, at the least, as any other effective process. It was deemed more consistent with economy, to form cuttings with sloped sides for the London and Croydon Railway, at New Cross and Forest Hill, than to drift through and to build tunnels; but as the event has transpired, probably the slopes have been the cause of more expenditure, than the latter expedient would have required. It may confidently be asserted, nevertheless, that open cuttings might have been made and their sides securely retained by constructions in the manner above indicated, not only for less money and in less time than tunnels would have consumed, but even for less than was expended in forming the cutting with slopes in the first instance.

It will be admitted, that whatever insecurity there may be in the sloped sides of a cutting, becomes greater, as the depth is increased, the inclination being the same; so that a slope of 40 feet in vertical height is not deemed so trustworthy as a similar slope in the same

place of 20 feet in height and, indeed, to give the same degree of security, as the height increases, the inclination of the slope must be increased. Consequently, the expense of a cutting with slopes, increases even in a greater degree than the mere additional depth would require and if it can be shown, that a cutting 65 deep, in the London clay, or other similar soil, may be made and its sides retained by efficient permanent constructions, at less cost per yard forward than the same cutting would require, with the slopes at which such soils can be trusted to stand,—it will be admitted, that greater advantage would be obtained by the use of such constructions, where the depth is greater; especially where such treacherous soils occur, as those through which the cuttings at New Cross and Forest Hill have been made.

It will not be exaggerating the case against sloped sides in clay cuttings, to assume, that they cannot be trusted at less than 1½ to 1, even up to 20 feet in vertical height, nor beyond 40 feet at 2 to 1; nor will it be extravagant to state the slopes for a cutting 65 feet deep, at 2½ to 1. Many instances, besides those of the Croydon Railway cuttings, give conclusive evidence that the London clay and the superposed strata which occur in connexion with it, will not stand at less than 3 to 1 when the vertical height much exceeds 65 feet; whilst the uncertainty connected with 'silty clays' and 'soapy earths,' exposed to the alternate action of air and water and of heat and cold, renders even slopes of that degree of inclination, a subject of constant anxiety and expense.

If then, safe and (so to speak) imperishable constructions, can be applied to retain the sides of a cutting in any soil that cannot be trusted at a less inclination than 2½ to 1, at less cost and in no greater time, than the excavation with such slopes could be made,—taking no account of subsequent cost for slips, or for the dry shafts and bushed drains, in some cases, or the gravel revetments and buttresses in others,—there can be no question, but that such constructions would be better than slopes.

The positive strength which such constructions should possess, depends, of course, in a great degree, upon the nature of the soil; its susceptibility of being affected by external influences and upon the presence or absence of such agencies; but it depends, even in a greater degree, upon the manner in which the constructions can be applied to the ground they are intended to retain. A very slight power would retain at rest a body, which the exertion of great force could not stop if once in motion and a half-brick counter-arch, set in close contact with undisturbed ground, would hold safely up, what three times the substance would not stop, if there were space and opportunity for motion between the ground and the brickwork.

It is impossible, therefore, to say what is the least strength which the retaining constructions must have, to be effective in any supposed case, even if the soil and the circumstances connected with it be known,—unless it can be determined in what manner or with what effect, as it regards disturbance and proximity, the constructions will be applied. There can be no question but that too much strength is better than too little, and generally it is cheaper to pay in materials, than in labour to save materials and in the kind of work under consideration, it will be always better to give mass enough to ensure sufficient strength, under any circumstances, than to count upon that degree of tact and care in the execution of the work, for rendering those constructions sufficient, which would be otherwise quite insufficient.

It would be for every engineer to decide upon the substance required under the circumstances of any particular case; that assumed in the accompanying diagrams (Figs. 3, 4, 5, & 6) is submitted as, in the judgment of the author, sufficient in ordinary cases of clay cuttings, if executed with materials and workmanship of fair average quality and such constructions may be applied in any such case, where the depth exceeds 40 feet and the slopes would require an inclination of more than 2 to 1, at less expense than that of forming slopes to the full depth. Of course, shoring to retain the ground, while the constructions are in progress, would form an important item in any such arrangement; but as the amount of earthwork in forming slopes, and the cost of contingencies connected with them when made, must increase, at least as much as the difficulty of temporarily retaining the ground increases, the proposed arrangement would not be deprived of its presumed advantage, as it regards economy, on this account.

The length of a compartment from centre to centre of two consecutive buttresses, being determined, according to the circumstances, to be 6, 7, or 8 yards forward of the cutting, a heading must be made to that extent and the vertical sides must be waled and shored throughout and, if necessary, close planked. The width of the cutting will depend, of course, upon the width of the way required—and upon the length transversely of the cutting—of the constructions on either side of it. In the diagrams, the width of way is taken at 22 feet clear for a double line of way of 4 feet 8½ inches gauge, with 6 feet between the lines, and 3 feet between the outer lines and the jambs of the buttresses; more space than enough for trains to pass safely, being considered unnecessary where there is, constantly recurring, room for escape for workmen, or others, on the line, in the deep bays which make up five-sixths of the whole length. The buttresses and the counter-arched retaining walls run in 10 feet on each side, thus requiring the cutting to be 42 feet wide and as much more as any planking or railing may render necessary.

The diagrams (Figs. 3 and 5) represent a
the level of the rails. It is assumed, that th
stand for the first 15 feet at less than 2
therefore, be cheaper to run out to that dep
50 feet from the rails, or about 52 feet in a
the bricklayer may follow up the excavator
work lying mostly on the side and out of th
the latter would run out the spoil without
being benched onwards and shored as he pro
partment, with its buttresses, invert, abutti
arches is complete in itself, the ground be
counter-arches as the work rises, the shorin
be sent on for use in the forward benches.

The invert may be turned upon footings in
the largest quantity of solid resisting matter
a height from the surface of the rails suffi
sumed at 14 feet 6 inches—a 14-inch bond
buttress to buttress, springing from skewbac
Upon the back of this arch the abutting bea
end and edge, bonded as a wall, with beds
over the haunches of the discharging arch
inverted arch turned upon it; so that altho
centre but 14 inches deep, it presents an a
three times that depth. The object of the
beam is to stiffen it and to bring down an
and pressure from the buttresses more effect

The built beam and its sustaining and s
be composed of particularly well-formed
quality, set in Roman cement or other qui
there may be no yielding to the pressure whi
thrown upon this part of the construction.

Another built beam, of greater depth, be
any inverted arch to stiffen it, is thrown acr
semi-circular arch, with its abutting ends ex

To relieve the work from water, a drain b
middle of the inverts, or side-drains being
through the buttresses, drain-shafts are carr
the buttresses against the springings of
within a few feet of the surface. These sl
open joints at intervals to admit drainage w
with the drains below, would prevent the pos
or accumulating about the backs of the co
the ground itself. It is proposed that the
semi-domed with bricks set dry and that the

and the walls also backed up, with good clean gravel, through which the surface water might percolate and pass freely down to the shafts.

The following estimates give the cost of forming 7 yards forward of an open clay cutting, 65 feet deep to the level of the rails, with slopes at 2½ to 1 and from a base 33 feet wide, at 2 feet below the surface of the rails—and of the cost of constructions as above described and shown in the diagrams. Fair average prices are taken on each side; the earthwork in the heading, where the sides are to be retained, is taken at a higher price than that in the open cutting with slopes, with a further charge for the setting, striking and use of shoring. Contingencies are not charged upon either mode of operation, because they may not be pre-supposed greater in the one than in the other.

WITH SLOPES.

	£.	s.	d.
29·3 perches of land, at £160 per acre	29	6	0
10,448½ cubic yards of earthwork, at 1s. 2d. per yard	609	9	6
	£638	15	6

WITH CONSTRUCTIONS.

	£.	s.	d.
7·64 perches of land, at £160 per acre	7	13	0
753 cubic yards of earthwork in open cutting above the top of constructions, at 1s. 2d. per yard	43	18	6
1720 ditto ditto in heading, at 1s. 6d. per yard	129	0	0
10 ditto clay punned at back of side walls, at 1s. 3d. per yard	0	12	6
86 ditto strong gravel ditto, at 3s. 6d. per yard	15	1	0
18 rods 184 feet superficial reduced stock brickwork, at £12 per rod	224	2	0
224½ feet extra to brickwork in cement, at £5 per rod	4	10	0
139½ feet ditto for picked bricks and in cement, at £7 per rod	3	12	0
311 feet ditto labour to skew-backs, at 1d. per foot	1	6	0
16 yards ditto rendering in cement back of drain shafts, at 2s. 6d. per yard	2	0	0
77 ft. 7 in. cube stone in coping, including labour and setting, at 6s. per foot	23	5	6
7 yards forward setting, striking, and use of shoring, at £3 per yard	21	0	0
Setting, striking, and use of moulds and centres	5	0	0
	481	0	6
DIFFERENCE, 32½ *per cent., or nearly one-third, in favour of constructions*	157	15	0
	£638	15	6

In the foregoing remarks and estimates, the suggested constructions are assumed to be of brickwork, for the obvious reason that the cases supposed being clay cuttings, brick is the material which would be most economical. Masonry, if it be cheaper, may, of course, be used with the same effect. Where a cutting intersects loose beds of laminated stone and particularly strata inclined to the horizon, so as to be unsafe with the ordinary slopes, such constructions may be most valuable and in cases where the sides of the cutting will stand nearly vertically by themselves, as in chalk, it may sometimes be useful to apply similar constructions of very slight character, to check the separation and fall of masses from the precipitous sides.

If the suggested constructions can thus be applied to cuttings with advantage, they may be held also to render embankments safer by diminishing their height; for the 32½ per cent. saved in the cutting may be applied to make it deeper, and so to diminish the adjacent embankment. Where an embankment would be made 50 feet high out of a cutting of similar depth, the latter may be made 65 feet deep and the former reduced thereby to 35 feet high and for the same money at most.

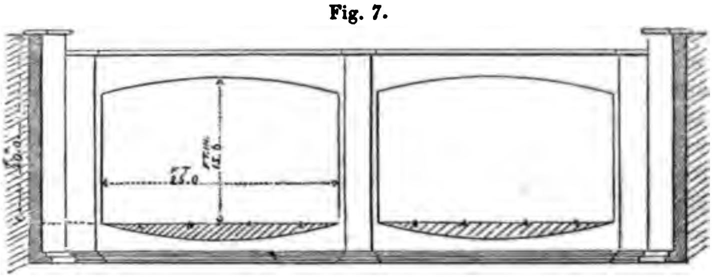
It is obvious, too, that these constructions present the means of security, when the stratum forming the base of any cutting is too weak to bear the weight of slopes or of retained sides, as the case may be, without rising between them. Sheet piling may be driven to any depth along the backs of the counter-arched walls, so as to be retained at the head by the walls and thus in effect the walls would be carried down to a safe depth, even through the weak stratum; whereas such piling at the toes of slopes is always found to be almost if not wholly useless, for the want of a stay to the head.

The immediate inducement for making the present communication was the circumstances of the deep cuttings on the Croydon Railway, lately detailed by Mr. Gregory; but it need not be shown that if such constructions as above described, could have been effectually applied in those cases, even though at a cost one-half more in proportion than the above estimate sets forth, the advantage arising from their use would have been far beyond anything that has been claimed; but it may not be out of place to show, in conclusion, that the expense of such works, as compared with ordinary retaining walls, would be greatly in favour of the former.

In the comparatively shallow cutting between Camden Town and Euston Square, before referred to, a length of 24 feet forward of the retaining walls on both sides, as originally built, and where the height is 20 feet, contains very nearly 17 rods of brickwork; whereas

permanently effective constructions of the kind above described (Figs. 7 and 8), with central piers in continuation of those which already exist for the bridges and galleries, would require, in the same length, less than $10\frac{1}{2}$ rods, or about $\frac{4}{5}$ths of the former quantity.

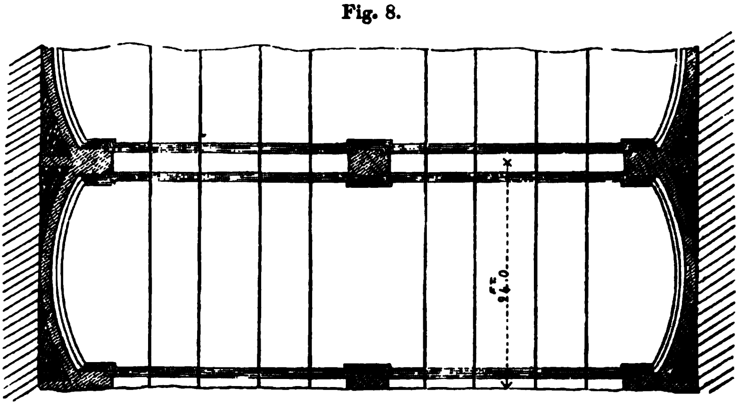
Fig. 7.



Application of the suggested Constructions to a Cutting similar to that for the Euston Incline.

SCALE.—1 inch to 20 feet.

Fig. 8.



Plan.

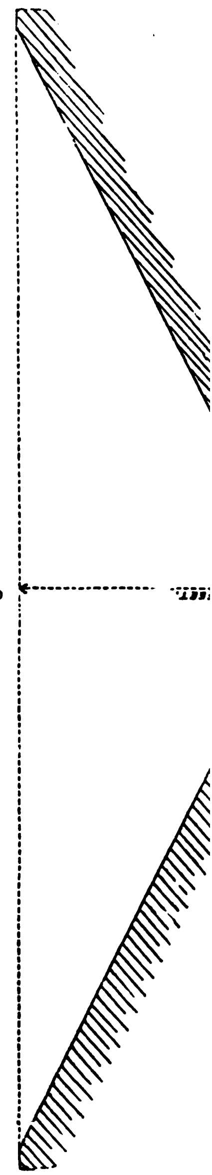
The paper is illustrated by six drawings (Nos. 3683 to 3688), showing the adaptation of the proposed constructions to various localities.

General Pasley stated, that the principle advocated by Professor Hosking, had already been put into practice by Mr. A. J. Adie, in the Chorley cutting, on the Bolton and Preston Railway. Maj.-Gen. Pasley.

The Chorley cutting was about 60 feet deep (Figs. 9, 10, and 11); it was cut through sand, which though dry at the summit, became wet and silty near the level of the forming. In the sand there existed large masses of clay which, after exposure to the weather, split from

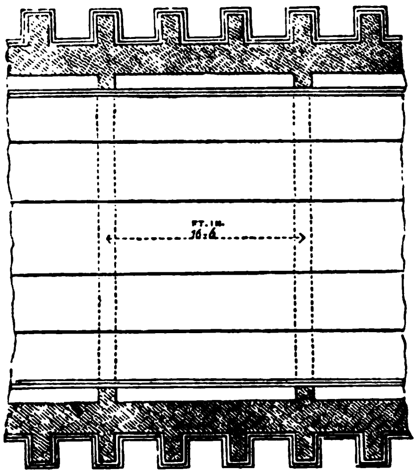
the top to the bottom. Fearing lest an ordinary wall might be forced forwards by this expansive action, and wishing to avoid the expense of a very thick wall, Mr. Adie introduced a series of arches or struts, traversing the railway at intervals of 15 feet from centre to centre. These struts consisted of two arches of rubble and rough ashlar masonry, placed back to back (Figs. 9 & 11). The lower arch springing from the side walls, at a height of 11 feet 4 inches, and rising to 15 feet in the centre. The thickness of the arches at the centre, where they combined and were formed for some distance on either side, by the same stones, was 12 inches, with a course of rough flag stones laid upon the strut to keep the joints dry.

Fig. 9.



The retaining walls were 3 feet 9 inches thick at the bott battering on the face to 2 feet in thicknes

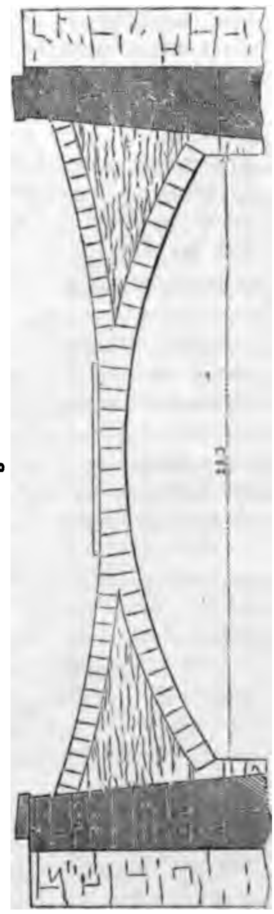
Fig. 10.



Plan of the Constructions in the Chorley Cutting.

SCALE.—1 inch to 16 feet.

Fig. 11.



Stone Strut, Chorley Cutting. SCALE.—1 inch to 8 feet.

buttresses were parallel and projected 2 feet 6 inches. The walls were built upon a layer of engine cinders, which Mr. Adie preferred to concrete and which he had found of great assistance in constructions in wet situations.

Captain Vetch said he was sure, that Professor Hosking would be gratified to learn, that his view had been already tested by a successful experiment in a cutting near the village of Moseley, on the line of the Birmingham and Gloucester Railway. Captain Vetch.

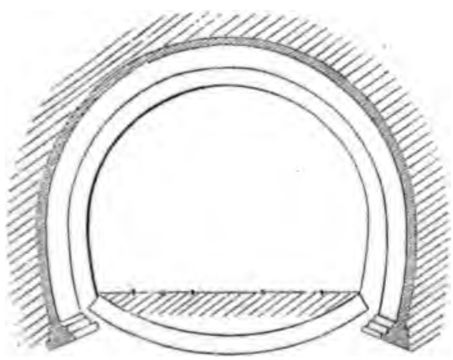
The average depth of the cutting was about 30 feet, with firm gravel and dry sand at the top, which became wet below, and terminated in a quicksand at the level of the line of the railway.

The authorities of the place had the power of compelling the construction of a tunnel for a distance of about 200 yards; but it was deemed the cheaper plan, in such shallow ground and with a

false foundation, to make an open cutting in the first place afterwards to insert the brick-work of the tunnel, if required.

The cutting was accordingly made and the sides left rough at as great an inclination as the nature of the ground would ac of; when the period approached for opening the railway, no defi arrangement about a tunnel having been made, it was deei provident to be prepared for such a work; Captain Vetch co: quently proposed to Captain Moorsom, the engineer and which with his concurrence, that at every 15 feet, a rib, or inverted ı of brick-work (Figs. 12, 13, and 14), should be thrown across ur

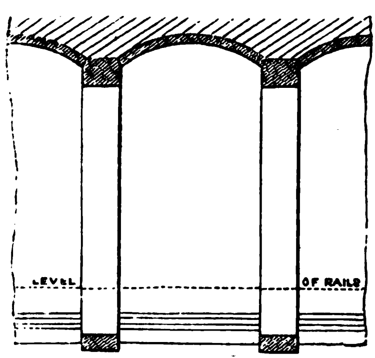
Fig. 12.



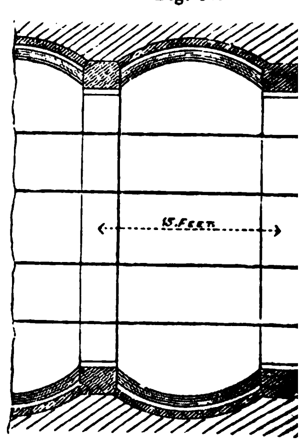
Moseley Tunnel.—Transverse section.

Fig. 14.

Fig. 13.



Moseley Tunnel.—Longitudinal section.



Moseley Tunnel.—Plan.

SCALE.—1 inch to 16 feet.

the railway and then to carry up, on the ends of these inverts, projecting buttresses with a curved batter; each pair of buttresses, on the same side of the way, to be connected by a concave retaining wall, abutting against them and each opposite pair of buttresses connected by mutual support by a flying buttress, thrown across and over the railway. This construction afforded complete security to the slopes and was executed at a moderate expense; it was, however, deemed prudent to conduct the concave side walls completely over the top and to make them abut on the flying buttresses, and so to form a complete tunnel at a very small expense; the buttresses, arches, and counter-arches, were all about 2½ feet square and the concave walling and roofing were only 9 inches thick, but were backed with a little concrete. Captain Vetch thought the form adopted, afforded the means of doing the most work at the least expense, the extreme convexity of the coombs connecting the ribs, presenting a dome form of resistance, where the pressure was greatest, permitted the thickness to be much reduced. The latter portions of the work were executed in great haste, yet he understood, that the work had stood well and he thought it a cheap, as well as an effectual mode of supporting very weak ground, in railway cuttings.

Had the principle of ribs and projecting buttresses not been acted upon, it would have been necessary (from the wet bottom), to have laid down a continuous inverted arch, while the side walls and roof must have been constructed of much greater substance.

The form of the tunnel, when finished, approached to the form of a 'caterpillar,' and it was distinguished as the 'caterpillar' construction. Captain Vetch presented a drawing (No. 3689), showing in detail all parts of the construction.

Professor Hosking said, that he had no knowledge whatever of the existence of either of these instances, until they were mentioned by General Pasley and Captain Vetch. There could be no doubt but that they severally exhibited the leading features of his design and tended, jointly, to a practical justification of the suggestions he had made, as to the design and arrangement of retaining constructions. It seemed to him quite certain, however, that the profession generally was as ignorant as he was, of these instances, or that it had not yet been suggested how the peculiarities which they exhibited might be varied and combined, so as to produce better and cheaper retaining walls to the opposed sides of open cuttings, since common retaining walls and slopes continued to be made in such cases up to the present time without any suspicion, it would appear, of the means which he had suggested of constructing effective retaining walls more cheaply than slopes could be made. Professo Hosking

Mr. Adie's were common retaining walls, with back counterforts at

short intervals and the strut merely short
unsupported work, but without any struc
intermediate portions and justifying but littl
of the constructions; whilst the strut itsel
sufficient for its duty, did not offer the res
coursed work afforded. It was obvious, tha
the strut, in Mr. Adie's example, was a par
that it might be thrown up by severe lateral
same pressure, would have a tendency to
segments push up the tops of the walls, aga
He thought, therefore, that the peculiar com
beam which he had suggested, was essentia
of which the arrangement was capable an
possess, in the more trying circumstances
In Mr. Adie's example, the strut was merely
walls; in Professor Hosking's design, it was
system in which it was placed.

The constructions of the Moseley tunnel
Vetch, exhibited the other essential peculiarit
design; but, singularly enough, the partic
springing-walls and counter-arches, ceased
combination, they would have been of mo
the tunnel ceased, and the cutting commenc

In a drifted tunnel, such constructions as
to form the Moseley tunnel, could hardly be
not with economy—and they would not be
cutting, because they depended wholly upo
over head, to keep the crown from being thr
of the ground upon the sides; they woul
straight abutment beam which had been sug

It was scarcely necessary to say, that the
tion referred to in these remarks, had nothi
taken independently of each other and of the c
was proposed to place them. The novelty c
taining walls, as Mr. Adie has strutted the wal
and in building buttress springing-walls to
walls, as Captain Vetch had applied them i
and all the merit Professor Hosking thoug
suggesting a combination of the two peculi
such constructive arrangements, as might fit
duty referred to, of retaining, securely and e
deep cuttings, particularly in clays or other

London: Printed by William Clowes and So